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MEMORANDUM FOR PRS (In-House Publication)

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SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-AB-2001-196**
Frank Mead, Jr., Bill Larson, Wayne Kalliomaa, "A Status Report of the X-50LR Program – A Laser Propulsion Program" (Abstract only)

33rd AIAA Plasmadynamics & Lasers Conference **(Statement A)**
(Maui, HI, 20-23 May 2002) **(Deadline: 15 October 2001)**

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PHILIP A. KESSEL Date
Technical Advisor
Space and Missile Propulsion Division

A STATUS REPORT OF THE X-50LR PROGRAM — A LASER PROPULSION PROGRAM

Please add a dash or a colon after "X-50LR Program"

Franklin B. Mead, Jr., C. William Larson, and Wayne M. Kalliomaa
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Abstract

In 1996, the Air Force Research Laboratory's Propulsion Division at Edwards AFB initiated a program that had as its main objective to launch a laser-propelled vehicle into a suborbital trajectory within a period of 5 years in order to demonstrate the concept and its attractive features. The concept was to be a nanosatellite in which the laser propulsion engine and satellite hardware were intimately shared. This concept was based upon a 1989 design developed at Rensselaer Polytechnic Institute under a Space Defense Initiative Office (SDIO) laser propulsion program.[1] The forebody aeroshell had been designed to act as an external compression surface (i.e., the airbreathing engine inlet). The afterbody served a dual function as a primary receptive optic (parabolic mirror) for the laser beam and as an external expansion surface (plug nozzle). The primary thrust structure was the centrally located annular shroud. The shroud provided air through inlets and acts as an energy absorption chamber for plasma formation. In the rocket mode, the air inlets were closed, and the afterbody and shroud combined to form the rocket thrust chamber and plug ("aerospike-type") nozzle. The full-scale vehicle was 1.4 meters in diameter with a dry mass of 120 kg. Fully fueled, this vehicle would have an initial mass of about 240 kg (i.e., a mass fraction of 0.5), and would be launched into orbit with a 100 megawatt-class infrared ground-based laser (GBL). This laser propelled vehicle would be a single-stage-to-orbit (i.e., airbreathing only to M=5 and 30 km; a laser thermal rocket, using liquid propellants, at higher altitudes and in space) using a combined-cycle pulsed detonation engine. Once in space, the Lightcraft was to use its one meter diameter optical system to provide, for example, Earth surveys from low Earth orbit (LEO) with ~~from~~ 8 to 15 cm resolution in the visible light frequencies. Such a device was simple, reliable, safe, environmentally clean, and could have a very high all azimuth on demand launch rate.

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The Lightcraft Technology Demonstration (LTD) program, initiated in 1996, was planned in three phases. Phase I, Lightcraft Concept Demonstration, was to demonstrate the feasibility of the basic concept. This phase ended successfully in December 1998. Under Phase I, performance was measured with pendulum impulse and piezoelectric thrust stands, shadowgraph studies were conducted, beam propagation energy measurements were made to 90 m, a pointing and tracking system was developed and demonstrated on horizontal wire-guided flights outdoors to 122 m, and outdoor vertical free-flights approaching 30 m were successfully conducted.[1,2,3,~~&~~4] Low Mach number wind tunnel tests were also accomplished with a 23-cm diameter model.[5] The basic conclusion of all this work was that the feasibility and basic physics of the Lightcraft concept had been adequately demonstrated, and that a much larger, 100 kW class laser would be required to completely accomplish Phase II.

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Phase II, Lightcraft Vertical Launches to Extreme Altitudes, was initiated in January 1999, and was a five-year effort designed to extend Lightcraft flights in sounding rocket trajectories to

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30 km with a 100 kW CO_2 laser. The first step of the Phase II vertical flight test program was to extend Lightcraft vertical free-flights to significantly higher altitudes in the range of 150 to 300 m using the 10 kW PLVTS laser.[5] Tenth-scale laser-powered vehicles were used. With this size vehicle, laser flight tests were conducted at the High Energy Laser Systems Test Facility (HELSTF), White Sands Missile Range (WSMR), New Mexico, using the 10 kW, Pulsed Laser Vulnerability Test System (PLVTS), CO_2, electric discharge laser. The first composite, ceramic shroud components for the Lightcraft vehicle were fabricated, laboratory tested for performance, and flight tested. Performance details were previously presented comparing the composite material shroud with the all-aluminum vehicles which had been used to that point in the program.

In January 2001, a new program was initiated to scale-up the initial Phase II vehicle to a 50-cm focal diameter completely functional flight vehicle. This program is named the X-50LR for Experimental 50-centimeter Laser Rocket. It borrowed certain aspects of the previous LTD program, but forged a new "team" concept with an appropriately modified schedule and funding. The details of this new program and its progress will be discussed. The results of Laboratory and outdoor flight test ing will be presented, along with the most recent progress towards a 100 kW isotopic CO_2 pulsed electric laser.

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